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GRAVITY WAVES

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Gravity waves contribute to the establishment of the thermal structure, small scale (80-100 km) fluctuations in velocity (50-80 m/sec) and density (20-30%, 0 to peak). Dominant gravity wave spectrum in the middle atmosphere: x-scale, <100 km; z-scale, >10 km; t-scale, <2 hr.

Theorists are beginning to understand middle atmosphere motions. There are two classes: Planetary waves and equatorial motions, gravity waves and tidal motions. The former give rise to variability at large scales, which may alter apparent mean structure. Effects include density and velocity fluctuations (velocity fluctuations are larger), induced mean motions, and stratospheric warmings which lead to the breakup of the polar vortex and cooling of the mesosphere. On this scale are also equatorial quasi-biennial and semi-annual oscillations.

Gravity wave and tidal motions produce large rms fluctuations in density and velocity. The magnitude of the density fluctuations compared to the mean density is of the order of the vertical wavelength, which grows with height. Relative density fluctuations are less than, or of the order of 30% below the mesopause (vertical wavelength of the order of 30 km or less). Such motions may cause significant and variable turbulence and diffusion. Sources include topography, convection, and wind shear. There is a strong seasonal variation in gravity wave amplitude.

Additional observations are needed to address and quantify mean and fluctuation statistics of both density and mean velocity, variability of the mean and fluctuations, and to identify dominant gravity wave scales and sources as well as causes of variability, both temporal and geographic. Useful data can come from satellite measurements - winds, temperatures and constituents; global means and variability, waves and turbulence. Other valuable data can originate from fixed ground sites: radar winds - energies, scales, temporal variability, fluctuation statistics at high resolution; lidar temperatures - wave amplitudes and scales, dynamics, temporal variability at high resolution; optical systems-wavelengths and phase speeds. Relevant measurements include temperature and density, horizontal velocities and wave energies, wave periods, wavelengths, phase speeds, and vertical velocities indicative of trends but not as readily related to density fluctuations.

The GRAM does a good job with the available data. It could be improved substantially with current knowledge if it incorporated better means, i.e. monthly values, and used better fluctuation statistics. Possible alternatives would be based on mean and fluctuation statistics and knowledge of variability to rms perturbation horizontal velocity, density, and knowledge of the causes of these perturbations.

Orbital perturbations arise from geomagnetic storms. 250 to 400 percent increases in density at polar latitudes occur under these conditions, giving rise to ten percent fluctuations in orbital velocity. Note that winds are thus not needed unless density variations are known to better than 20 percent.